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*Figure the 6th represents,*

|   |   |   |
|---|---|---|
| <i>A A</i> , The Kidneys.                     | } | <i>F</i> , The Bladder.   |
| <i>a a</i> , The <i>Renes Succenturiati</i> . |   | <i>g g</i> , The Spermatick Vessels, Veins and Arteries.                      |
| <i>b b</i> , The <i>Ureters</i> .             |   | <i>h h</i> , The <i>Testes</i> , with the Branches of the Veins and Arteries. |
| <i>c c</i> , The Crural Veins and Arteries.   |   | <i>i i</i> , The <i>Epididymides</i> .  |
|   |   | <i>k k</i> , The <i>Deferentia</i> .  |
|   |   | <i>l</i> , The <i>Penis</i> .   |
|   |   | <i>m m</i> , <i>Vesiculæ Seminales</i> .                                      |
| <i>D</i> , <i>Arteria Magna</i> .             | } | <i>n n</i> , Two Glands, from whence a thick Juice might be press'd out.      |
| <i>e</i> , <i>Vena Cava</i> .                 |   | <i>o</i> , The <i>Balanus</i> .   |

*An Estimate of the Degrees of the Mortality of Mankind, drawn from curious Tables of the Births and Funerals at the City of Breslaw; with an Attempt to ascertain the Price of Annuities upon Lives. By Mr. E. Halley, R.S.S.*

THE Contemplation of the *Mortality of Mankind*, has besides the *Moral*, its *Physical* and *Political* Uses, both which have been some years since most judiciously considered by the curious Sir *William Petty*, in his *Natural and Political Observations on the Bills of Mortality of London*, owned by Captain *John Graunt*. And since in a like Treatise on the Bills of *Mortality of Dublin*.

*Dublin.* But the Deduction from those Bills of *Mortality* seemed even to their Authors to be defective: First, In that the *Number* of the People was wanting. Secondly, That the *Ages* of the People dying was not to be had. And Lastly, That both *London* and *Dublin* by reason of the great and casual Accession of *Strangers* who die therein, (as appeared in both, by the great Excess of the *Funerals* above the *Births*) rendered them incapable of being Standards for this purpose; which requires, if it were possible, that the People we treat of should not at all be changed, but die where they were born, without any Adventitious Increase from Abroad, or Decay by Migration elsewhere.

This *Defect* seems in a great measure to be satisfied by the late curious Tables of the Bills of *Mortality* at the City of *Breslaw*, lately communicated to this Honourable Society by Mr. *Justell*, wherein both the *Ages* and *Sexes* of all that die are monthly delivered, and compared with the number of the *Births*, for Five Years last past, viz. 1687, 88, 89, 90, 91, seeming to be done with all the Exactness and Sincerity possible.

This City of *Breslaw* is the Capital City of the Province of *Silesia*; or, as the *Germans* call it, *Schlesia*, and is situated on the Western Bank of the River *Oder*, anciently called *Viadrus*; near the Confines of *Germany* and *Poland*, and very nigh the Latitude of *London*. It is very far from the Sea, and as much a *Mediterranean* Place as can be desired, whence the Confluence of *Strangers* is but small, and the Manufacture of Linnen employs chiefly the poor People of the place, as well as of the Country round about; whence comes that sort of Linnen we usually call your *Silesie Linnen*; which is the chief, if not the only Merchandize of the place. For these Reasons the People of this City seem most pro-

per for a *Standard* ; and the rather, for that the *Births* do, a small matter, exceed the *Funerals*. The only thing wanting is the Number of the whole People, which in some measure I have endeavoured to supply by comparison of the *Mortality* of the People of all Ages, which I shall from the said Bills trace out with all the Acuracy possible.

It appears that in the Five Years mentioned, *viz.* from 87 to 91 inclusive, there were *born* 6193 Persons, and *buried* 5869 ; that is, born *per Annum* 1238, and *buried* 1174 ; whence an *Encrease* of the People may be argued of 64 *per Annum*, or of about a 20th part, which may perhaps be ballanced by the Levies for the *Emperor's* Service in his Wars. But this being contingent, and the Births certain, I will suppose the People of *Breslaw* to be encreased by 1238 *Births* annually. Of these it appears by the same Tables, that 348 do die *yearly* in the *first Year* of their *Age*, and that but 890 do arrive at a full *Years Age* ; and likewise, that 198 do die in the *Five Years* between 1 and 6 compleat, taken at a *Medium* ; so that but 692 of the Persons *born* do survive *Six* whole *Years*. From this *Age* the Infants being arrived at some degree of Firmness, grow less and less *Mortal* ; and it appears that of the whole People of *Breslaw* there die *yearly*, as in the following Table, wherein the upper Line shews the *Age*, and the next under it the *Number* of Persons of that *Age dying yearly*.

7 . 8 9 . . 14 . 18 . 21 . 27 . 28 . . 35 .  
 11 . 11 . 6 .  $5\frac{1}{2}$  . 2 .  $3\frac{1}{2}$  5 6  $4\frac{1}{2}$   $6\frac{1}{2}$  9 . 8 . 7 . 7 .

36 . 42 . 45 49 54 . 55 . 56 . 63  
 8 .  $9\frac{1}{2}$  8 . 9 . 7 . 7 . 10 11 . 9 . 9 . 10 . 12

70 71 . 72 77 81 84 . 90 91 .  
 $9\frac{1}{2}$  14 9 . 11  $9\frac{1}{2}$  6 . 7 . 3 . 4 . 2 . 1 . 1 . 1 .

98 . 99 . 100 .  
 0 .  $\frac{1}{5}$  .  $\frac{3}{5}$

And where no *Figure* is placed over, it is to be understood of those that die between the Ages of the preceding and consequent *Column*.

From this Table it is evident, that from the Age of 9 to about 25 there does not die above 6 *per Annum* of each *Age*, which is much about one *per Cent.* of those that are of those *Ages*: And whereas in the 14, 15, 16, 17 *Tears* there appear to die much fewer, as 2 and  $3\frac{1}{2}$ , yet that seems rather to be attributed to Chance, as are the other Irregularities in the Series of *Ages*, which would rectifie themselves, were the number of Years much more considerable, as 20 instead of 5. And by our own Experience in *Christ-Church Hospital*, I am informed there die of the *Young Lads*, much about one *per Cent. per Annum*, they being of the foresaid *Ages*. From 25 to 50 there seem to die from 7 to 8 and 9 *per Annum* of each *Age*; and after that to 70, they growing more *crasie*, though the number be much diminished, yet the *Mortality encreases*, and there are found to die 10 or 11 of each *Age per Annum*: From thence the number of the *Living* being grown very small, they gradu-

Gradually decline till there be none left to *die*; as may be seen at one View in the Table.

From these Considerations I have formed the *adjoin- ed Table*, whose Uses are manifold, and give a more just *Idea* of the *State* and *Condition* of *Mankind*, than any thing yet extant that I know of. It exhibits the *Number* of *People* in the City of *Breslaw* of all *Ages*, from the *Birth* to extream *Old Age*, and thereby shews the *Chances* of *Mortality* at all *Ages*, and likewise how to make a certain Estimate of the value of *Annuities* for *Lives*, which hitherto has been only done by an imaginary *Valuation*: Also the *Chances* that there are that a *Person* of any *Age* proposed does live to any other *Age* given; with many more, as I shall hereafter shew. This *Table* does shew the *number* of *Persons* that are living in the *Age* current annexed thereto, as follows:

| Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. |
|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 1             | 1000          | 8             | 680           | 15            | 628           | 22            | 585           | 29            | 539           | 36            | 481           | 7             | 5547          |               |               |
| 2             | 855           | 9             | 670           | 16            | 622           | 23            | 579           | 30            | 531           | 37            | 472           | 14            | 4584          |               |               |
| 3             | 798           | 10            | 651           | 17            | 616           | 24            | 573           | 31            | 523           | 38            | 463           | 21            | 4270          |               |               |
| 4             | 750           | 11            | 653           | 18            | 610           | 25            | 567           | 32            | 515           | 39            | 454           | 28            | 3964          |               |               |
| 5             | 732           | 12            | 646           | 19            | 604           | 26            | 560           | 33            | 507           | 40            | 445           | 35            | 3604          |               |               |
| 6             | 710           | 13            | 640           | 20            | 598           | 27            | 553           | 34            | 499           | 41            | 436           | 42            | 3178          |               |               |
| 7             | 692           | 14            | 634           | 21            | 592           | 28            | 546           | 35            | 490           | 42            | 427           | 49            | 2709          |               |               |
|               |               |               |               |               |               |               |               |               |               |               |               | 55            | 2194          |               |               |
| Age<br>Curt.  | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | Age.<br>Curt. | Per-<br>sons. | 63            | 1694          |               |               |
| 43            | 417           | 50            | 346           | 57            | 272           | 64            | 202           | 71            | 131           | 78            | 58            | 70            | 1204          |               |               |
| 44            | 407           | 51            | 335           | 58            | 262           | 65            | 192           | 72            | 120           | 79            | 49            | 77            | 692           |               |               |
| 45            | 397           | 52            | 324           | 59            | 252           | 66            | 182           | 73            | 109           | 80            | 41            | 84            | 253           |               |               |
| 46            | 387           | 53            | 313           | 60            | 242           | 67            | 172           | 74            | 98            | 81            | 34            | 100           | 107           |               |               |
| 47            | 377           | 54            | 302           | 61            | 232           | 68            | 162           | 75            | 88            | 82            | 28            |               |               |               |               |
| 48            | 367           | 55            | 292           | 62            | 222           | 69            | 152           | 76            | 78            | 83            | 23            |               |               |               |               |
| 49            | 357           | 56            | 282           | 63            | 212           | 70            | 142           | 77            | 68            | 84            | 20            |               |               |               |               |
|               |               |               |               |               |               |               |               |               |               |               |               |               | 34000         |               |               |
|               |               |               |               |               |               |               |               |               |               |               |               |               | Sum Total.    |               |               |

Thus it appears, that the whole People of *Breslaw* does consist of 34000 *Souls*, being the *Sum Total* of the *Persons* of all *Ages* in the *Table*: The first use hereof

is to shew the Proportion of *Men* able to bear *Arms* in any *Multitude*, which are those between 18 and 56, rather than 16 and 60; the one being generally too weak to bear the *Fatigues* of *War* and the Weight of *Arms*, and the other too crasie and infirm from *Age*, notwithstanding particular Instances to the contrary. Under 18 from the *Table*, are found in this City 11997 Persons, and 3950 above 56, which together make 15947. So that the Residue to 34000 being 18053 are Persons between those *Ages*. At least one half thereof are Males, or 9027 : So that the whole Force this City can raise of *Fencible Men*, as the *Scotch* call them, is about 9000, or  $\frac{3}{4}$ , or somewhat more than a quarter of the *Number* of *Souls*, which may perhaps pass for a Rule for all other places.

The *Second Use* of this *Table* is to shew the differing degrees of *Mortality*, or rather *Vitality* in all *Ages* ; for if the number of Persons of any *Age* remaining after one year, be divided by the difference between that and the number of the *Age* proposed, it shews the *odds* that there is, that a Person of that *Age* does not die in a *Year*. As for Instance, a Person of 25 *Years* of *Age* has the odds of 560 to 7 or 80 to 1, that he does not die in a *Year* : Because that of 567, living of 25 years of *Age*, there do die no more than 7 in a *Year*, leaving 560 of 26 *Years* old.

So likewise for the *odds*, that any Person does not die before he attain any proposed *Age*: Take the *number* of the remaining Persons of the *Age* proposed, and divide it by the difference between it and the number of those of the *Age* of the Party proposed; and that shews the *odds* there is between the Chances of the Party's living or dying. As for Instance ; What is the *odds* that a Man of 40 lives 7 *Years* : Take the number of Persons of 47 years, which in the *Table* is 377, and sub-

subtract it from the number of Persons of 40 years, which is 445, and the *difference* is 68 : Which shews that the *Persons dying* in that 7 years are 68 , and that it is 377 to 68 or  $5\frac{1}{2}$  to 1, that a Man of 40 does live 7 Years. And the like for any other *number of Years*.

*Use III.* But if it be enquired at what number of *Years*, it is an even Lay that a Person of any *Age* shall die, this Table readily performs it : For if the *number* of Persons *living* of the *Age* proposed be *halved*, it will be found by the *Table* at what Year the said *number* is reduced to half by *Mortality* ; and that is the *Age*, so which it is an even Wager, that a Person of the *Age* proposed shall arrive before he *die*. As for Instance ; A Person of 30 Years of *Age* is proposed, the number of that *Age* is 531, the half thereof is 265, which number I find to be between 57 and 58 Years; so that a Man of 30 may reasonably expect to live between 27 and 28 Years.

*Use IV.* By what has been said, the *Price* of *Insurance* upon *Lives* ought to be regulated, and the difference is discovered between the *price* of ensuring the *Life* of a *Man* of 20 and 50, for Example: it being 100 to 1 that a Man of 20 dies not in a year, and but 38 to 1 for a Man of 50 Years of *Age*.

*Use V.* On this depends the Valuation of *Annuities* upon *Lives* ; for it is plain that the *Purchaser* ought to pay for only such a part of the value of the *Annuity*, as he has Chances that he is living ; and this ought to be computed yearly, and the Sum of all those yearly Values being added together, will amount to the value of the *Annuity* for the *Life* of the Person proposed. Now the present value of Money payable after a term of years, at any given rate of Interest, either may be had from Tables already computed ; or almost as compendiously,  
by



by the Table of Logarithms : For the Arithmetical Complement of the Logarithm of Unity and its yearly Interest ( that is, of 1, 06 for Six *per Cent.* being 9, 974694.) being multiplied by the number of years proposed, gives the present value of One Pound payable after the end of so many years. Then by the foregoing Proposition, it will be as the number of Persons living after that term of years, to the number dead ; so are the Odds that any one Person is Alive or Dead. And by consequence, as the Sum of both or the number of Persons living of the Age first proposed, to the number remaining after so many years, (both given by the Table) so the present value of the yearly Sum payable after the term proposed, to the Sum which ought to be paid for the Chance the person has to enjoy such an Annuity after so many Years. And this being repeated for every year of the persons Life, the Sum of all the present Values of those Chances is the true Value of the Annuity. This will without doubt appear to be a most laborious Calculation, but it being one of the principal Uses of this Speculation, and having found some *Compendia* for the Work, I took the pains to compute the following Table, being the short Result of a not ordinary number of Arithmetical Operations ; It shews the Value of Annuities for every Fifth Year of Age, to the Seventieth, as follows.

| Age. | Years Purchase. | Age. | Years Purchase. | Age. | Years Purchase. |
|------|-----------------|------|-----------------|------|-----------------|
| 1    | 10,28           | 25   | 12,27           | 50   | 9,21            |
| 5    | 13,40           | 30   | 11,72           | 55   | 8,51            |
| 10   | 13,44           | 35   | 11,12           | 60   | 7,60            |
| 15   | 13,33           | 40   | 10,57           | 65   | 6,54            |
| 20   | 12,78           | 45   | 9,91            | 70   | 5,32            |

This shews the great Advantage of putting Money into the present *Fund* lately granted to their Majesties, giving 14 *per Cent. per Annum*, or at the rate of 7 years purchase for a Life; when young Lives, at the usual rate of Interest, are worth above 13 years Purchase. It shews likewise the Advantage of young Lives over those in Years; a Life of Ten Years being almost worth 13½ years purchase, whereas one of 36 is worth but 11.

*Use V.* Two Lives are likewise valuable by the same Rule; for the number of Chances of each single Life, found in the Table, being multiplied together, become the Chances of the Two Lives. And after any certain Term of Years, the Product of the two remaining Sums is the Chances that both the Persons are living. The Product of the two Differences, being the numbers of the Dead of both Ages, are the Chances that both the Persons are dead. And the two Products of the remaining Sums of the one Age multiplied by those dead of the other, shew the Chances that there are that each Party survives the other: Whence is derived the Rule to estimate the value of the Remainder of one Life after another. Now as the Product of the Two Numbers in the Table for the Two Ages proposed, is to the difference between that Product and the Product of the two numbers of Persons deceased in any space of time, so is the value of a Sum of Money to be paid after so much time, to the value thereof under the Contingency of Mortality. And as the aforesaid Product of the two Numbers answering to the Ages proposed, to the Product of the Deceased of one Age multiplied by those remaining alive of the other; So the Value of a Sum of Money to be paid after any time proposed, to the value of the Chances that the one Party has that he survives the other whose number of Deceased you made use of, in the second Term of the proportion. This perhaps  
may

may be better understood, by putting  $N$  for the number of the younger Age, and  $n$  for that of the Elder ;  $T, y$  the deceased of both Ages respectively, and  $R, r$  for the Remainders; and  $R + T = N$  and  $r + y = n$ . Then shall  $Nn$  be the whole number of Chances;  $Nn - Ty$  be the Chances that one of the two Persons is living,  $Ty$  the Chances that they are both dead ;  $Ry$  the Chances that the elder Person is dead and the younger living ; and  $rT$  the Chances that the elder is living and the younger dead. Thus two Persons of 18 and 35 are proposed, and after 8 years these Chances are required. The Numbers for 18 and 35 are 610 and 490, and there are 50 of the First Age dead in 8 years, and 73 of the Elder Age. There are in all  $610 \times 490$  or 298900 Chances ; of these there are  $50 \times 73$  or 3650 that they are both dead. And as  $298900$ , to  $298900 - 3650$ , or  $295250$  : So is the present value of a Sum of Money to be paid after 8 years, to the present value of a Sum to be paid if either of the two live. And as  $560 \times 73$ , so are the Chances that the Elder is dead, leaving the Younger ; and as  $417 \times 50$ , so are the Chances that the Younger is dead, leaving the Elder. Wherefore as  $610 \times 490$  to  $560 \times 73$ , so is the present value of a Sum to be paid at eight years end, to the Sum to be paid for the Chance of the Youngers Survivance ; and as  $610 \times 490$  to  $417 \times 50$ , so is the same present value to the Sum to be paid for the Chance of the Elders Survivance.

This possibly may be yet better explained by expounding these Products by Rectangular Parallelograms, as in *Fig. 7.* wherein  $AB$  or  $CD$  represents the number of persons of the younger Age, and  $DE, BH$  those remaining alive after a certain term of years; whence  $CE$  will answer the number of those dead in that time : So  $AC, BD$  may represent the number

of the Elder Age ;  $AE, BI$  the Survivors after the same term ; and  $CE, DI$ , those of that Age that are dead at that time. Then shall the whole Parallelogram  $ABCD$  be  $Nn$ , or the Product of the two Numbers of persons, representing such a number of Persons of the two Ages given ; and by what was said before, after the Term proposed the Rectangle  $HD$  shall be as the number of Persons of the younger Age that survive, and the Rectangle  $AE$  as the number of those that die. So likewise the Rectangles  $AI, FD$  shall be as the Numbers, living and dead, of the other Age. Hence the Rectangle  $HI$  shall be as an equal number of both Ages surviving. The Rectangle  $FE$  being the Product of the deceased, or  $\gamma\gamma$ , an equal number of both dead. The Rectangle  $GD$  or  $R\gamma$ , a number living of the younger Age, and dead of the Elder : And the Rectangle  $AG$  or  $r\gamma$  a number living of the Elder Age, but dead of the younger. This being understood, it is obvious, that as the whole Rectangle  $AD$  or  $Nn$  is to the *Gnomon*  $FABDEG$  or  $Nn - \gamma\gamma$ , so is the whole number of Persons or Chances, to the number of Chances that one of the two Persons is living : And as  $AD$  or  $Nn$  is to  $FE$  or  $\gamma\gamma$ , so are all the Chances, to the Chances that both are dead ; whereby may be computed the value of the Reversion after both Lives. And as  $AD$  to  $GD$  or  $R\gamma$ , so the whole number of Chances, to the Chances that the younger is living and the other dead ; whereby may be cast up what value ought to be paid for the Reversion of one Life after another, as in the case of providing for Clergy-mens Widows and others by such Reversions. And as  $AD$  to  $AG$  or  $r\gamma$ , so are all the Chances, to those that the Elder survives the younger. I have been the more particular, and perhaps tedious, in this matter, because it is the Key to the Case of Three Lives, which of it self would not have been so easie to comprehend.

VII. If Three Lives are proposed, to find the value of an Annuity during the continuance of any of those three Lives. The Rule is, *As the Product of the continual multiplication of the Three Numbers, in the Table, answering to the Ages proposed, is to the difference of that Product and of the Product of the Three Numbers of the deceased of those Ages, in any given term of Years ; So is the present value of a Sum of Money to be paid certainly after so many Years, to the present value of the same*

same Sum to be paid, provided one of those three Persons be living at the Expiration of that term. Which proportion being yearly repeated, the Sum of all those present values will be the value of an Annuity granted for three such Lives. But to explain this, together with all the Cases of Survivance in three Lives: Let  $N$  be the Number in the Table for the Younger Age,  $n$  for the Second, and  $v$  for the Elder Age; let  $T$  be those dead of the Younger Age in the term proposed,  $y$  those dead of the Second Age, and  $u$  those of the Elder Age; and let  $R$  be the Remainder of the younger Age,  $r$  that of the middle Age, and  $s$  the Remainder of the Elder Age. Then shall  $R+T$  be equal to  $N$ ,  $r+y$  to  $n$ , and  $s+u$  to  $v$ , and the continual Product of the three Numbers  $Nn v$  shall be equal to the continual Product of  $R+T$   $\times$   $r+y$   $\times$   $s+u$ , which being the whole number of Chances for three Lives is compounded of the eight Products following. (1)  $R r s$ , which is the number of Chances that all three of the Persons are living. (2)  $r s T$ , which is the number of Chances that the two Elder Persons are living, and the younger dead. (3)  $R p y$  the number of Chances that the middle Age is dead, and the younger and Elder living. (4)  $R r u$  being the Chances that the two younger are living, and the elder dead. (5)  $s T y$  the Chances that the two younger are dead, and the elder living. (6)  $r T u$  the Chances that the younger and elder are dead, and the middle Age living. (7)  $R y u$ , which are the Chances that the younger is living, and the two other dead. And Lastly and Eighthly,  $T y u$ , which are the Chances that all three are dead. Which latter subtracted from the whole number of Chances  $Nn v$ , leaves  $Nn v - T y u$  the Sum of all the other Seven Products; in all of which one or more of the three Persons are surviving.

To make this yet more evident, I have added Fig. 8. wherein these Eight several Products are at one view exhibited. Let the rectangled Parallelepipedon  $A B C D E F G H$  be constituted of the sides  $A B$ ,  $G H$ , &c. proportional to  $N$  the number of the younger Age;  $A C$ ,  $B D$ , &c. proportional to  $n$ ; and  $A G$ ,  $C E$ , &c. proportional to the number of the Elder, or  $v$ . And the whole Parallelepipedon shall be as the Product  $Nn v$ , or our whole number of Chances. Let  $R P$  be as  $R$ , and  $A P$  as  $T$ : let  $C L$  be as  $r$ , and  $L n$  as  $y$ ; and  $G N$  as  $s$ , and  $N A$  as  $u$ ; and let the Plain  $P R e a$  be made parallel to the plain

plain  $ACGE$ ; the plain  $NVbY$  parallel to  $ABCD$ ; and the plain  $LXTQ$  parallel to the plain  $ABGH$ . And our first Product  $Rr\epsilon$  shall be as the Solid  $STWIFZeb$ . The Second, or  $r\epsilon Y$  will be as the Solid  $ERYZQSMI$ . The Third,  $R\epsilon y$ , as the Solid  $RHOVVIST$ . And the Fourth,  $Rrv$ , as the Solid  $ZabDWXIK$ . Fifthly,  $\epsilon Yy$ , as the Solid  $GQRSIMNO$ . Sixthly,  $rYv$ , as  $IKLMGYZA$ . Seventhly,  $Ryv$ , as the Solid  $IKPOBXVW$ . And Lastly,  $AIKLMNOP$  will be as the Product of the 3 numbers of persons dead, or  $Yyv$ . I shall not apply this in all the cases thereof for brevity sake; only to shew in one how all the rest may be performed, let it be demanded what is the value of the Reversion of the younger Life after the two elder proposed. The proportion is as the whole number of Chances, or  $Nnv$  to the Product  $Ryv$ , so is the certain present value of the Sum payable after any term proposed, to the value due to such Chances as the younger person has to bury both the elder, by the term proposed; which therefore he is to pay for. Here it is to be noted, that the first term of all these Proportions is the same throughout, viz.  $Nnv$ . The Second changing yearly according to the Decrease of  $R, r, \epsilon$ , and Increase of  $Y, y, v$ . And the third are successively the present values of Money payable after one, two, three, &c. years, according to the rate of Interest agreed on. These numbers, which are in all cases of Annuities of necessary use, I have put into the following Table, they being the Decimal values of One Pound payable after the number of years in the Margent, at the rate of 6 per Cent.

Years

| Years. | Present va-<br>lue of 1 l. | Years. | Present va-<br>lue of 1 l. | Years. | Present va-<br>lue of 1 l. |
|--------|----------------------------|--------|----------------------------|--------|----------------------------|
| 1      | 0,9434                     | 19     | 0,3305                     | 37     | 0,1158                     |
| 2      | 0,8900                     | 20     | 0,3118                     | 38     | 0,1092                     |
| 3      | 0,8396                     | 21     | 0,2941                     | 39     | 0,1031                     |
| 4      | 0,7921                     | 22     | 0,2775                     | 40     | 0,0972                     |
| 5      | 0,7473                     | 23     | 0,2618                     | 45     | 0,0726                     |
| 6      | 0,7050                     | 24     | 0,2470                     | 50     | 0,0543                     |
| 7      | 0,6650                     | 25     | 0,2330                     | 55     | 0,0406                     |
| 8      | 0,6274                     | 26     | 0,2198                     | 60     | 0,0303                     |
| 9      | 0,5919                     | 27     | 0,2074                     | 65     | 0,0227                     |
| 10     | 0,5584                     | 28     | 0,1956                     | 70     | 0,0169                     |
| 11     | 0,5268                     | 29     | 0,1845                     | 75     | 0,0126                     |
| 12     | 0,4970                     | 30     | 0,1741                     | 80     | 0,0094                     |
| 13     | 0,4688                     | 31     | 0,1643                     | 85     | 0,0071                     |
| 14     | 0,4423                     | 32     | 0,1550                     | 90     | 0,0053                     |
| 15     | 0,4173                     | 33     | 0,1462                     | 95     | 0,0039                     |
| 16     | 0,3936                     | 34     | 0,1379                     | 100    | 0,0029                     |
| 17     | 0,3714                     | 35     | 0,1301                     |        |                            |
| 18     | 0,3503                     | 36     | 0,1227                     |        |                            |

It were needless to advertise, that the great trouble of working so many Proportions will be very much alleviated by using Logarithms; and that instead of using  $N n v - T y v$  for the Second Term of the Proportion in finding the value of Three Lives, it may suffice to use only  $T y v$ , and then deducting the Fourth Term so found out of the Third, the Remainder shall be the present value sought; or all these Fourth Terms being added together, and deducted out of the value of the certain Annuity for so many Years, will leave the value of the contingent Annuity upon the Chance of Mortality of all those three Lives. For Example; Let there be Three Lives of 10, 30, and 40 years of Age proposed, and the Proportions will be thus :

As 661 in 531 in 445 or 156190995, or  $N n v$   
to 8 in 8 in 9, or 576, or  $T y v$  for the first year, so 0,9434 to 0,00000348  
to 15 in 16 in 18, or 4320, for the second year, so 0,8900 to 0,00002462  
to 21 in 24 in 28, or 14112 for the third year, so 0,8396 to 0,00008123  
to 27 in 32 in 38, for the fourth year, so 0,7921 to 0,00016530  
to 33 in 41 in 48, for the fifth year, so 0,7473 to 0,00031071  
to 39 in 50 in 58, for the sixth year, so 0,7050 to 0,00051051

And

And so forth to the 60th year, when we suppose the elder Life of Forty certainly to be expired; from whence till Seventy we must compute for the First and Second only, and from thence to Ninety for the single youngest Life. Then the Sum Total of all these Fourth Proportionals being taken out of the value of a certain Annuity for 90 Years, being 16,58 years Purchase, shall leave the just value to be paid for an Annuity during the whole term of the Lives of three Persons of the Ages proposed. And note, that it will not be necessary to compute for every year singly, but that in most cases every 4th or 5th year may suffice, interpoling for the intermediate years *secundum artem*.

It may be objected, that the different *Salubrity* of places does hinder this Proposal from being *universal*; nor can it be denied. But by the number that die, being 1174. *per Annum* in 34000, it does appear that about a 30th part die yearly, as Sir *William Petty* has computed for *London*; and the number that die in Infancy, is a good Argument that the Air is but indifferently salubrious. So that by what I can learn, there cannot perhaps be one better place proposed for a Standard. At least 'tis desired that in imitation hereof the Curious in other Cities would attempt something of the same nature, than which nothing perhaps can be more useful.

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